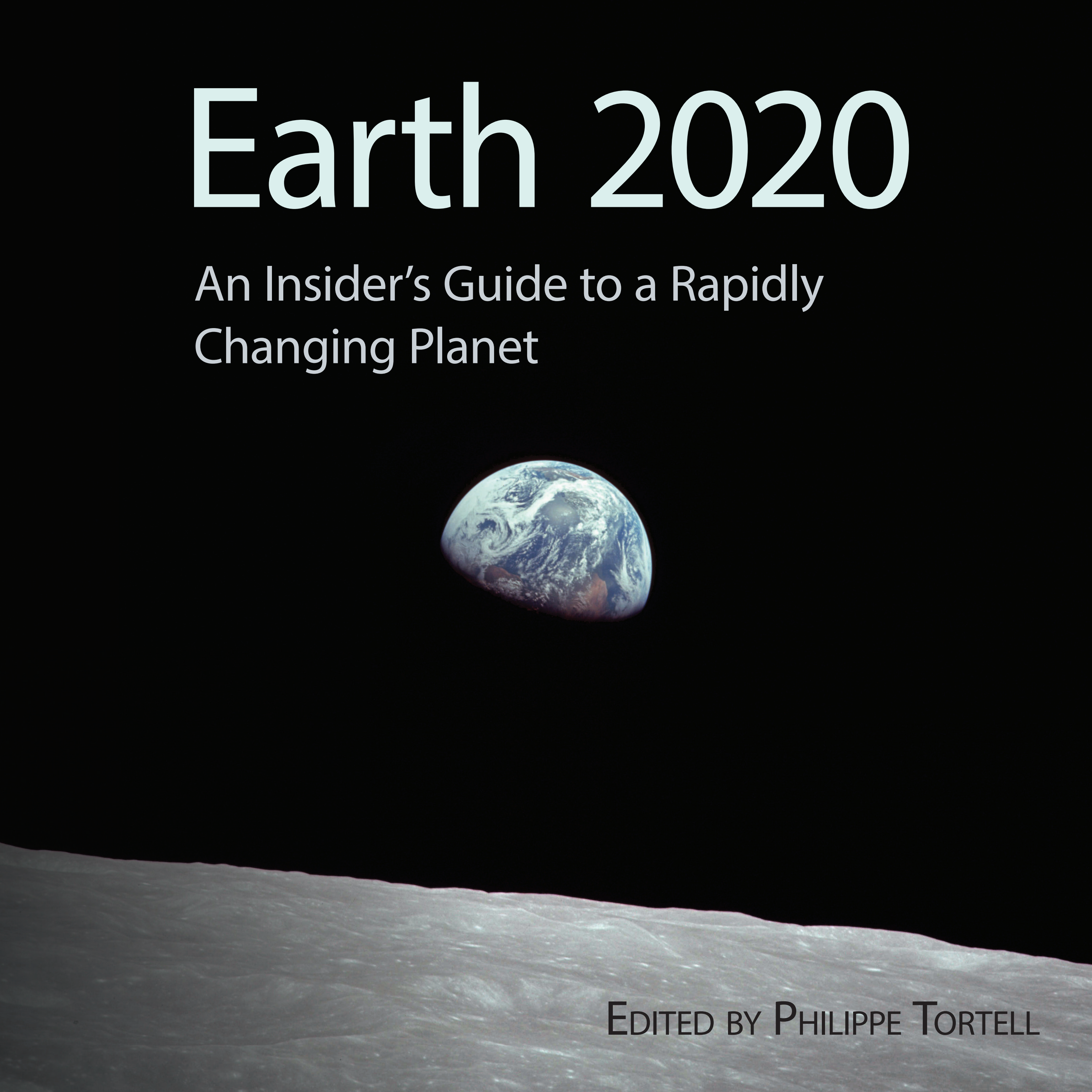
Earth 2020

An Insider's Guide to a Rapidly Changing Planet



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Energy

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Homer's epic poem from the eighth century BC recounts the legend of Odysseus' return to Ithaca after the Trojan War. What should have been a journey of a few weeks across the Aegean Sea, became, in Homer's tale, a ten-year ordeal plagued by natural hazards, monsters and divine malfeasance. Imagine the different outcome if Odysseus had owned a diesel outboard motor, a GPS to plot his route through the islands, an emergency radio to track storms and uncooperative winds, and an echo sounder to avoid submerged rocks (and mermaids). And with a cell phone, he could have called his wife Penelope to let her know he'd been delayed, keeping her lurking suitors at bay. Today, Google Maps charts Odysseus' trip from modern day Turkey to Greece as taking less than twenty-four hours, more like a weekend road trip than an Odyssey.

There can be no doubt that modern energy has transformed how humans move, eat, live and play, while also radically altering our impact on Planet Earth. Over the past 10,000 years, new power-producing technologies have been the foundation of modern societies. In human history, today is the energy anomaly. Supported by energy, more people live longer now than in any other time in the history of our species, with access to vastly improved healthcare, sanitation and seemingly limitless opportunities for travel. Energy has also benefited social mobility; no longer are 70–90% of humans serving as serfs and slaves needed to farm and transport goods; in many countries, traditional 'women's work'

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of cooking, laundry and cleaning has been drastically cut by energy-driven appliances (and with men sharing the work!).

But whenever there is progress, there is also regress and unanticipated consequences. Both coal mining and natural gas and oil production, including refining and combustion, affect land use and pollute water and air. Uranium is mined to produce nuclear-powered electricity, creating long-lived radio-active waste. Hydropower entails the damming of rivers, which results in the flooding of tracts of land and impacts upstream and downstream habitat, as well as water flow and quality. Even renewable energy sources, like wind power turbines or solar photovoltaics, require energy and rare Earth minerals in their construction. This 'embedded energy' can be traced through all consumer goods. Energy production and generation also impact human health; respiratory difficulties from bad air quality affect people living near industrial and energy-producing facilities. The World Health Organization estimates that 4.2 million people annually die prematurely from poor air quality.[1] And we should not forget the social costs of energy extraction, transport and use, which range from civil unrest around the location of energy production facilities and pipelines, to corruption, fraud, human rights abuses and large-scale geopolitical engagements. Energy is the largest business on the planet. With energy comes power, both literally and figuratively.

Sometimes, energy production systems experience catastrophic failures. Take, for example, the nuclear accidents at Three Mile Island, Chernobyl and Fukushima Daiichi, oil spills of the Exxon Valdez and BP Deepwater Horizon; or natural gas pipeline explosions in San Bruno, California or Andover, Massachusetts. Such disasters have enormous environmental impacts, and they can also leave a long-term political legacy, as was the case for the Santa Barbara oil spill. On January 28, 1969, an oil platform blowout in the Santa Barbara Channel released three million gallons of oil into the sea floor, creating a massive oil slick on the surface ocean that lead to the death of thousands of birds, fish and marine mammals. Widespread public outcry following this event (the largest oil spill in US history at the time), ushered in sweeping new environmental legislation, and galvanized a burgeoning political and social movement that culminated with the first Earth Day, just one year later.

Over the past half-century since the Santa Barbara oil spill, our energy dependence has grown significantly. Global energy consumption has increased by roughly 45% per capita since 1970, with an accompanying rise in global atmospheric CO_2 concentrations from around 320 parts per million (ppm) in 1970 to over 410 ppm in 2019 (with the annual mean in 2020 likely coming close to 415 ppm). The trend appears to be continuing unabated; in 2018, the world used 3% more energy than the previous year, with accompanying annual CO_2 emissions increasing at 2% to 37 billion metric tons of carbon dioxide.[2] The fear of a climate tipping point looms large, and energy system decarbonization is now more critical than ever.

The good news is that there has been significant progress on the transition to alternative energy sources. Economic incentives, including tax credits, feed-in-tariffs and other subsidies, have stimulated research, development, deployment and investment, and helped reduce the costs of renewable energy globally. As a result, the addition of low carbon energy production capacity has surpassed expert predictions in scale and speed. Innovation and global investment in renewables like solar and wind power topped $300 billion per year for the fifth year running, and 2018 saw near record numbers of renewables, and lower carbon natural gas dominate new energy installations.

The bad news is that our progress has not been nearly enough. Overall global growth in energy demand is outstripping decarbonization efforts, and fossil fuel consumption continues to increase as more people are using more energy around the planet. Today, roughly 80% of energy used still comes from fossil fuels including coal oil and natural gas. This is down from 94% in 1970, but the absolute increase in global energy demand means greater total emissions.

Researchers often discuss 'energy transitions', examining past societal shifts from wood to fossil fuels; or charting future courses from high carbon fossil fuels to low-carbon futures. While these transitions can be locally transformative, global energy transitions have not been substitutive, but additive. While the EU and North America have transitioned from wood as the primary energy source, global wood consumption remains as high as ever. This underscores the fact that the deployment of new energy technologies remains local, shaped by regional priorities and resulting policies. In other words, energy systems are more than just a collection of coordinated technologies, they enshrine social practices and values. There is no *one* global energy system; energy is not distributed, delivered and used equally around the world.

As a privileged citizen of an industrialized country, my experience of energy is vastly different from most of the world's population. When I wake up, shut off the alarm clock, turn on the light, start the hot shower and the coffee maker, and get cold milk from the refrigerator, energy use is almost invisible. When I flip on the light switch, I expect light. This is the privilege of the energy rich, the roughly 2.2 billion people of the 7.7 billion on the planet today who have the luxury of not having to think about energy. For these people, there is more than enough energy for basic comforts, health, food, transportation and wellbeing. There is enough for them to travel by airplane and car, to use cell phones and have Jacuzzis, extra freezers and nose-hair trimmers. This is not to say that energy use is uniform even within energy rich countries; energy disparities do exist, and some citizens in these countries still experience energy poverty.

Abundant energy has enabled rapid economic growth of industrialized societies, and this development has been responsible for the bulk of historical greenhouse gas emissions. But today, energy demand in many rich countries is flat to declining. In 2018, the twenty-eight European Union countries had flat or negative energy consumption growth due to policies supporting increased system efficiencies, investments in renewables and a mild winter. While reducing greenhouse gas emissions has become a modern rallying cry for the energy rich, others often have different priorities.

At the other end of the spectrum are the energy poor, the 1.1 billion people who live without access to electricity; and an additional 2.5 billion without access to modern cooking fuels. In these societies, lighting is often provided by candles or kerosene lanterns, while wood, dung, or charcoal provide energy for cooking and heating. Cooking over a three-stone fire requires significant amounts of both wood and time. Fire is dangerous, and it also creates smoky particulate matter which causes respiratory and eyesight problems, mostly in women and children who do the bulk of global wood gathering and cooking. For these people, whose meagre energy use has not contributed to global climate change, affordability and access to energy is paramount.

In the energy middle, you find 4.4 billion global citizens with access to modern sources of energy, but with varying degrees of reliability and affordability. Here, flicking on a light switch does not guarantee illumination. Until recently, residents of Katmandu, Nepal, were connected to the electric grid, but struggled to get sufficient power.[3] The city provided schedules of when different neighborhood residents could expect to have electricity, and many residents invested in backup solar and inverter systems. However, recent engineering and political reforms have changed this situation, and now residents have a reliable power supply, and only some industries are without power for four hours a day. Now, small businesses no longer have need for their expensive and polluting diesel generators for backup power, and they have enough electricity to run machinery and expand production. Instead of being invisible, energy access drives and shapes personal activities and economic growth.

Globally, energy demand, and associated greenhouse gas emissions, are growing most rapidly in the energy middle. Since 2000, per capita energy demand in China and India has grown by roughly 250% and 50%, respectively, and these development-driven trends continue. In just one year, 2018, energy demand grew by about 8% in India and 4% in China, as compared to a decrease of 0.6% in the European Union. Increasing energy demands in the developing world come with environmental and health impacts. In big cities like New Delhi or Cairo, air pollution is at record levels and urban residents suffer the consequences.[4]

While local and regional impacts of energy use can be managed if political will, technological acumen and economic investments align, addressing a changing global climate requires coordinated global action. The Paris Agreement, drafted in 2015 and signed in 2016, with nearly 200 signatory countries representing 89% of global emissions, constituted a start at collective action for a collective problem.[5] But so far, only two countries (Morocco and The Gambia) are on track to meet their <1.5°C Paris commitments, highlighting the challenges of transforming and adapting legacy energy systems.[6] The International Energy Agency estimates that current investments in renewable and clean energy resources must increase from $900 billion in 2018 to $2.3 trillion per year to meet the Paris Agreement's aggressive greenhouse gas reduction targets, while providing the energy needs for the planet's projected population of almost 10 billion by 2050.[7] The required transformation goes far beyond building new energy production plants and battery storage capacity; rather we require a systematic change in how we use energy — deep efficiency — and how we shift demand to accommodate significant use of variable renewable resources like wind and solar.

As we build our energy systems to reduce greenhouse gas emissions, we must also adapt them to the realities of climate change. Rising sea levels, intensified storms and stronger hurricanes threaten communities and their energy infrastructures. Current energy systems were not designed to withstand the 200 mph windstorm gusts, massive wildfires, floods, or 20-foot tidal surges. As record strength typhoons, cyclones and hurricanes batter vulnerable landscapes in Asia, Africa and the Americas, the fragility and criticality of energy infrastructures are underscored. When the power goes out, gas pumps and credit cards no longer work, cell phone service goes down and streetlights go dark. At home, food in refrigerators begins to rot, water no longer flows and electric heat and cooling systems stop working, leaving people vulnerable to extreme temperatures and disease outbreaks. Here again, the impacts fall disproportionately on the world's poorer populations. When Hurricane Maria hit Puerto Rico in 2017, over 1,000 people died in the aftermath. After Cyclones Idai and Kenneth hit Mozambique six weeks apart in March and April 2019, the risk of waterborne diseases like cholera was a major part of the emergency response.

Humanity now faces the daunting challenges of creating future energy systems that can both mitigate and adapt to changing climates across countries with different economic realities. Many communities and utilities are already adapting to new climate vulnerabilities by replacing wooden power poles with concrete and installing new meters and switches to allow grid operators to better detect and respond to power outages.[8] For example, more resilient cables and flood-proof equipment, coupled with the relocation of substations out of flood zones can enhance the resilience of core energy systems. The use of advanced technologies, including drones, is now helping to remotely assess and monitor damage from storms and ensure more rapid recovery. Some utilities are building in system redundancy, upgrading distribution networks, and investing in micro-grids to provide energy to critical infrastructure. But planning for novel risks is difficult. New patterns of floods, droughts, fires and other natural disasters heighten societal vulnerabilities and force communities to relocate and fortify energy and other human infrastructures.

Today, people live with dramatically different levels of energy access and use; yet we face a common threat in climate change. The energy rich, the energy poor and those in-between have different needs, risks and responsibilities. Responding to this planetary-scale threat requires simultaneous reduction of greenhouse gas emissions to near-zero, and adaptation of infrastructure to emerging (though uncertain) climate risks. All of this, while still providing energy access to a rapidly growing global population. No pressure.

Our future depends on how we will collectively make and use energy. This will be shaped by how we design, travel and live in our cities, communities and homes. Today, a zero-carbon energy system pushes the limits of technology and faces immense political and economic barriers. With the EU Green Deal goal of a carbon neutral Europe by 2050, and at least €100 billion to support it, this is a critical first step.[9] Whether we like it or not, our energy systems are changing. It remains to be seen how they can be adapted to support our collective futures on Earth.

As we look forward, humility should accompany our energy system transitions. The ancient Greeks believed that hubris led to punishment and suffering. This is the tale of Odysseus, who was punished for his arrogance, and of Prometheus, who stole fire from the Gods as a gift to humanity. Praying to the weather gods will not save us from the next hurricane, fire, or the impacts of a changing climate. We should not lose faith in science or political systems, but we might want an extra set of oars at the ready. They may come in handy when that diesel motor sputters out.

Endnotes

1. World Health Organization, 'Ambient air pollution: Health impacts', https://www.who.int/airpollution/ambient/health-impacts/en/

2. M. Muntean, D. Guizzardi, E. Schaaf, M. Crippa, E. Solazzo, J. G. J. Olivier and E. Vignati, *Fossil CO2 emissions of all world countries — 2018 Report*, Luxembourg: Publications Office of the European

Union, 2018, https://ec.europa.eu/jrc/en/publication/fossil-co2-emissions-all-world-countries-2018-report; BP, *Statistical Review of World Energy 2019*, London: BP, 2019, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf

3. B. Sangraula, 'How Nepal got the electricity flowing', *The Christian Science Monitor*, 16 January 2017, https://www.csmonitor.com/World/Asia-South-Central/2017/0116/How-Nepal-got-the-electricity-flowing
4. See also 'Air' by Jon Abbatt in this volume.
5. Available at https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf
6. A. Erickson, 'Few countries are meeting the Paris climate goals. Here are the ones that are', *The Washington Post,* 11 October 2018, https://www.washingtonpost.com/world/2018/10/11/few-countries-are-meeting-paris-climate-goals-here-are-ones-that-are/
7. International Energy Agency, *World Energy Investment Report 2019,* Paris: International Energy Agency, 2019, https://www.iea.org/wei2019/overview/
8. F. Stern, S. Hendel-Blackford, K. Leung, I. T. Rogrigo Leal and D. Vitoff, 'Extreme weather alert: How utilities are adapting to a changing climate', *Utility Dive*, 6 March 2019, https://www.utilitydive.com/news/extreme-weather-alert-how-utilities-are-adapting-to-a-changing-climate/549297/
9. European Commission, 'A European Green Deal: Striving to be the first climate-neutral continent', https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en; European Commission, '2050 long-term strategy', https://ec.europa.eu/clima/policies/strategies/2050_en